CORRELATIONS FOR YIELD AND SPECIFIC GRAVITY BETWEEN POTATO TUBERLING AND SECOND YEAR FIELD GENERATIONS

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Abstract

Individual hills of one 50-hill plot from each of 24 randomly chosen tuberling families were harvested in 1988 and 1989. Within each 50-hill plot, five hills were selected based on horticultural characteristics, such as shape, size, smoothness, and freedom from defects to form the population selected for horticultural characteristics (HC). From the remaining 45 hills, the five highest specific gravity hills were selected to form the population selected for specific gravity (SG). The HC and SG populations from 1988 and 1989 were planted in a randomized complete block design with two replications of six hills in 1989 and 1990, respectively. There was a significant positive correlation for yield and for specific gravity between the tuberling generation and the second year field generation in both 1988-89 and 1989-90. There was no correlation between yield and specific gravity in the second year field generation in either the SG or HC populations for 1989 and 1990. In selecting within the second year field generation on the basis of horticultural characteristics, a clone from the HC population was 1.9 and 1.7 times more likely to be selected in 1989 and 1990, respectively, than a clone from the SG population.

Compendio

Los sitios individuales, de una parcela de 50 sitios por cada una de 24 familias provenientes de tubérculos y escogidas al azar, se cosecharon en 1988 y 1989. Dentro de cada parcela de 50 sitios se seleccionaron cinco sitios, en base a características hortícolas tales como forma, tamaño, tersura y ausencia de defectos para formar con ellos una población seleccionada por características hortícolas (HC). De los 45 sitios restantes se seleccionaron los cinco con gravedad específica más alta, para formar una población seleccionada por gravedad específica (SG). Las poblaciones HC y SG obtenidas en 1988 y 1989 se plantaron en 1989 y 1990 respectivamente, utilizando

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un diseño de bloque completo al azar con dos repeticiones de seis sitios. Se observó una correlación positiva significativa en rendimiento y gravedad específica entre las generaciones provenientes de tubérculos y la generación de campo del segundo año, tanto en 1988-89 como en 1989-90. No hubo correlación entre el rendimiento y la gravedad específica en la generación de campo del segundo año ni en la poblacion SG ni en la población HC, tanto en 1989 como en 1990. Al seleccionar la generación de campo del segundo año, sobre la base de características hortícolas, un clon de la población HG fue 1.9 y 1.7 veces más apropiado para ser seleccionado en 1989 y 1990, respectivamente, que un clon de la población SG.

Introduction

True seeds obtained from potato hybridizations are usually planted in the greenhouse to produce the seedling generation. After harvest, tubers from these seedlings are subsequently planted in the field to produce the first clonal or tuberling generation (2). The efficiency of selecting within either the seedling or the tuberling generation has been questioned by numerous researchers (1, 6, 7, 9, 14, 17, 18). In general, Maris (16) found that there was little correlation of general impression, number of tubers per plant, mean tuber weight, date of emergence, haulm type, under-water weight, number of stems per plant, and plant height of a clone between the tuberling and later generations. However, several studies have shown that higher yielding seedlings tend to produce higher yielding progeny (3, 4, 5, 6, 16). After adjusting for maturity, Maris (15) concluded that tuber yield and under-water weight for unselected fourth year potato clones from twelve crosses were independent.

Haynes *et al.* (12), conducted a survey at three-year intervals of advanced potato breeding clones in the USDA potato breeding program from 1972 to 1987 and determined that there was a significant negative correlation between yield and specific gravity for round white potatoes in three of the six years of the survey. However, there was a significant negative correlation of yield and specific gravity for russet potatoes in only one of the six years of the survey.

To determine the effect of early generation selection on the basis of horticultural characteristics, Haynes and Wilson (13) harvested one complete plot of 50 hills in 24 randomly chosen families in the tuberling generation and measured yield and specific gravity. At harvest, tubers from five plants per family were selected on the basis of horticultural characteristics, such as size, shape, smoothness, and freedom from defects, to form the population selected for horticultural characteristics (HC). From the remaining 45 hills, the five with the highest specific gravity were selected to form the population selected for specific gravity (SG). Those hills not selected for either horticultural characteristics or specific gravity formed the unselected population. They found a significant negative correlation

between yield and specific gravity in both the population selected for horticultural characteristics (HC) and the population selected for high specific gravity (SG). However, selection on the basis of horticultural characteristics resulted in a population of significantly higher yielding plants whose average specific gravity was significantly greater than in the unselected population. The present study is a continuation of this earlier work.

The purposes of this study are: (1) to determine the correlation for yield and specific gravity between the potato tuberling and second year field generations in populations selected in the tuberling generation for horticultural characteristics or high specific gravity; (2) to determine the correlation for yield and specific gravity within the second year field generation for these two populations; and (3) to determine if clones selected for horticultural characteristics in the tuberling generation are more likely to be selected for horticultural characteristics in the second year field generation than clones selected for high specific gravity in the tuberling generation.

Materials and Methods

Details on the derivation of the seedling and tuberling generations used in this study have been reported in an earlier study (13). Twenty-four families in the tuberling generation were randomly chosen, irregardless of skin color, in the field in 1988 and 1989 at Presque Isle, Maine, for complete harvest of one 50 hill plot. From the 1988 and 1989 tuberling populations tubers from five plants per family were selected on the basis of horticultural characteristics to form the population selected for horticultural characteristics in 1988 (HC88) and 1989 (HC89), respectively. From among the remaining 45 hills not selected for horticultural characteristics tubers from five plants per family were selected on the basis of high specific gravity to form the population selected for specific gravity in 1988 (SG88) and 1989 (SG89), respectively. In these tuberling populations, there were 17 and 16 clones in 1988 and 1989, respectively, which were selected on the basis of horticultural characteristics and which would also have been selected on the basis of specific gravity if they had not already been selected for the HC populations.

On 30 May 1989 and 28 May 1990 tubers from the 1988 and 1989 selected populations, respectively, were planted on the Chapman Farm, Presque Isle, Maine, on a plaisted gravelly loam soil in a randomized complete block design with two replications of six hills per selection. Standard cultural practices were followed to control insects, diseases, and grasses. No irrigation was available. On 16 August and 22 August 1989 and 16 August and 23 August 1990, respectively, plants were top-killed with a split application of Diquat at the standard commercial rate, and, subsequently, the remaining vine residue removed by mechanical vine beater. On 1 September 1989 and 31 August 1990, respectively, the plots were harvested by

digger and tubers picked up by hand. Selections in the field on the basis of horticultural characteristics were made in both replications in both years completely independent of tuberling population origin. If the clone was selected on the basis of horticultural characteristics in both replications, it was saved for planting the next year. If the clone was selected in only one of the two replications, it was not saved. The tubers from each plot were weighed on a Toledo scale to the nearest 45 g (0.1 lb) and specific gravity was determined by the weight-in-air and weight-in-water method on a 3,000-4,000 g sample, where available, using a Toledo balance within a month of harvest.

Correlation coefficients of: (1) yield in the 1988 and 1989 tuberling generations with yield in the 1989 and 1990 second year field generations, respectively; (2) specific gravity in the 1988 and 1989 tuberling generations with specific gravity in the 1989 and 1990 second year field generations, respectively; and (3) yield in the 1989 and 1990 second year field generations with specific gravity in the 1989 and 1990 second year field generations, respectively, were calculated for the population overall and for the original HC and SG populations involved. Finally, the ratio of horticulturally selected clones in the second year field generation from the horticulturally selected populations in the tuberling generations to those from the specific gravity selected populations in the tuberling generations was calculated.

Results and Discussion

The 1988 and 1989 growing seasons were relatively dry early in the season, but rainfall was generally adequate from mid-season to harvest. There was adequate rainfall for the 1990 growing season. Temperatures were near normal during 1988 and 1989 but considerably higher than normal during the 1990 growing season.

There was a significant positive correlation between yield in the tuberling generation and the second year field generation for both 1988-89 (0.51 to 0.65) (Table 1) and 1989-90 (0.33 to 0.47) (Table 2). These results agree with those of numerous other researchers (3, 4, 5, 6, 16). There was also a significant positive correlation between specific gravity in the tuberling generation and the second year field generation for both 1988-89 (0.40 to 0.62) (Table 3) and 1989-90 (0.40 to 0.73) (Table 4). The positive correlation between specific gravity in the two generations was not as large in the population previously selected for specific gravity as in the population previously selected for horticultural characteristics.

Within the second year field generation, there was no significant correlation between yield and specific gravity in either the population previously selected for horticultural characteristics or the population previously selected for specific gravity. The significant negative correlation between yield and

TABLE 1.—*Correlation coefficients of yield in 1988 (YLD88), yield in 1989 (YLD89), specific gravity in 1988 (GR88), and specific gravity in 1989 (GR89) for the population selected for horticultural characteristics in 1988 (top line), the population selected for specific gravity in 1988 (middle line) and the combination of the two populations in 1988 (bottom line).*

Variables	*YLD89*	*GR88*	*GR89*
YLD88	0.51**	-0.40**	-0.11ns
	0.64**	-0.45**	-0.07ns
	0.65**	-0.64**	-0.26**
YLD89		-0.21	-0.10ns
		-0.29**	-0.02ns
		-0.41**	-0.17**
GR88			0.62**
			0.40**
			0.58**

*,** Significant at the 5% and 1% levels, respectively.
nsNot significant.

TABLE 2.—*Correlation coefficients of yield in 1989 (YLD89), yield in 1990 (YLD90), specific gravity in 1989 (GR89) and specific gravity in 1990 (GR90) for the population selected for horticultural characteristics in 1989 (top line), the population selected for specific gravity in 1989 (middle line), and the combination of the two populations in 1989 (bottom line).*

Variables	YLD90	GR89	GR90
YLD89	0.33**	-0.34**	-0.29**
	0.40**	-0.29**	0.02ns
	0.47**	-0.52**	-0.23**
YLD90		-0.03ns	0.07ns
		-0.07ns	0.11ns
		-0.21**	0.02ns
GR89			0.73**
			0.40**
			0.58**

*,** Significant at the 5% and 1% levels, respectively.
nsNot significantly different from zero.

specific gravity in the tuberling generation for both the population selected for horticultural characteristics and the population selected for specific gravity (13) no longer appears in the second year field generation. Several explanations for these phenomena can be envisioned. This may be due to the variation in sampling a single hill in the tuberling generation versus sampling 2 six-hill plots in the second year field generation. A high specific

TABLE 3.—*Average yield per hill in grams and the average specific gravity by family overall and for the populations selected for horticultural characteristics and high specific gravity for the second year field generation clones grown in 1989.*

	YIELD			SPECIFIC GRAVITY[1]		
Pedigree	Overall	HC	SG	Overall	HC	SG
B0835	765	900	585	76	73	80
B0836	765	855	630	70	67	73
B0838	675	765	540	78	78	77
B0845	675	765	540	78	75	81
B0850	945	1035	810	72	69	75
B0854	900	945	855	63	61	65
B0864	540	540	585	71	71	71
B0867	675	765	540	78	79	77
B0879	765	810	675	77	76	79
B0884	765	810	765	76	73	80
B0892	810	900	720	74	73	75
B0903	855	990	765	72	69	74
B0905	720	720	720	79	76	81
B0909	765	900	630	88	81	93
B0910	675	810	495	65	66	64
B0913	855	900	765	74	72	77
B0919	945	1035	900	70	65	75
B0927	675	765	495	79	76	83
B0931	855	945	675	82	80	85
B0933	900	945	900	73	71	75
B0941	765	765	720	79	76	82
B0944	855	900	855	74	65	81
B0950	720	810	675	78	77	79
B0957	630	765	540	72	68	75
Mean	765	855	675	75	73	77

[1]1.0 omitted from the specific gravity columns.

gravity or high yielding genotype as a single hill may average quite less at the twelve hill stage. It may be due to the different growing conditions represented by the two years of the generational study or to an interaction of genotypes with the growing environment. It may also be due to inherently different physiological mechanisms between the generation whose seed tubers were produced in the greenhouse and the generation whose seed tubers were produced in the field. Several researchers have suggested that the environmental growing conditions or storage conditions of the mother tuber may influence subsequent generations (8, 10, 11, 19).

Within the second year field generation the average specific gravity of the clones in the population originally selected for specific gravity was greater than the average specific gravity of the clones in the population originally selected for horticultural characteristics in both 1989 ($t=6.72$, $P<0.01$)

TABLE 4.—*Average yield per hill in grams and the average specific gravity by family overall and for the populations selected for horticultural characteristics and high specific gravity for the second year field generation clones grown in 1990.*

	YIELD			SPECIFIC GRAVITY[1]		
Pedigree	Overall	HC	SG	Overall	HC	SG
B0968	630	675	630	66	63	68
B0971	585	585	540	73	70	77
B0975	585	675	540	65	62	67
B0980	495	585	450	69	67	70
B0984	585	720	450	70	68	72
B0986	495	495	450	69	66	72
B0988	540	585	540	69	68	70
B0989	540	540	495	75	74	75
B0992	495	585	405	81	81	82
B0996	540	585	450	63	60	65
B0998	495	540	495	60	60	61
B1001	405	495	360	64	60	67
B1006	540	585	495	68	67	69
B1011	405	495	315	65	66	63
B1014	450	585	270	68	65	72
B1021	405	495	360	72	69	75
B1023	540	495	540	73	71	75
B1030	585	630	540	63	61	66
B1035	495	495	495	69	68	69
B1036	450	495	360	67	61	76
B1038	495	540	450	66	64	67
B1067	675	720	675	69	68	70
B1069	495	720	180	65	68	62
B1070	495	495	450	62	60	64
Mean	540	585	450	68	66	70

[1]1.0 omitted from the specific gravity columns.

(Table 3) and 1990 ($t = 5.09$, $P < 0.01$) (Table 4). However, the correlations of specific gravity between the tuberling generation and the second year field generation in both years of the study for the population originally selected for specific gravity were smaller than the correlations for the population originally selected for horticultural characteristics, indicating that there is less variability for specific gravity in the population originally selected for horticultural characteristics. This is also reflected in the standard error of the mean: the standard error of the mean specific gravity being greater in the population originally selected for specific gravity than for horticultural characteristics (7.9 vs. 7.0 in 1989 and 8.2 vs 7.0 in 1990).

Within the second year field generation the average yield per hill of the clones originally selected for horticultural characteristics was greater than the average yield per hill of the clones in the population originally

selected for specific gravity in both 1989 ($t=7.78$, $P<0.01$) (Table 3) and 1990 ($t=5.09$, $P<0.01$) (Table 4). In this case, the correlations of yield per hill between the tuberling generation and the second year field generation in both years of the study for the population originally selected for horticultural characteristics were smaller than the correlations for the population originally selected for specific gravity. However, the standard errors of the mean yield per hill in the populations originally selected for horticultural characteristics and for specific gravity are approximately the same.

Among the genotypes that were selected on the basis of horticultural characteristics in the second year field generation, a genotype which was previously selected on the basis of horticultural characteristics in the tuberling generation was 1.9 and 1.7 times more likely to be selected in 1989 and 1990, respectively, than a genotype which was previously selected on the basis of specific gravity in the tuberling generation (Table 5).

Among the clones in the second year field generation selected on the basis of horticultural characteristics for further testing, 66% and 64% were from the tuberling populations originally selected for horticultural characteristics in 1988 and 1989, respectively. Thus, 34% and 36% of the tuberling populations originally selected for specific gravity in 1988 and 1989, respectively, were selected on the basis of horticultural characteristics in the second year field generation. There was less variability for specific gravity in the second year field generation among the clones from the population originally selected for horticultural characteristics than among the clones from the population originally selected for specific gravity, suggesting that performance in the tuberling generation is more indicative of performance for specific gravity in the second year field generation for the populations originally selected for horticultural characteristics. However, the greater observed variability in specific gravity in the second year field generation among the clones in the population originally selected for specific gravity appeared to also occur in horticultural characteristics. Thus, high specific gravity lines with desirable horticultural characteristics were selected in the

TABLE 5.—*Number of clones saved from the second year field generation in 1989 and 1990 from the tuberling populations selected for horticultural characteristics, HC88 and HC89, or specific gravity, SG88 and SG89, respectively.*

Population	Year of Selection	Saved	Not Saved	Total	Percentage Saved
SG88	1989	27	91	118	23
HC88	1989	52	66	118	44
Total	1989	79	157	236	33
SG89	1990	10	104	114	9
HC89	1990	18	100	118	15
Total	1990	28	204	232	12

second year field generation that normally would already have been discarded. These results would suggest that where the breeding goal is to develop horticulturally acceptable high specific gravity clones less selection pressure should be placed on horticultural characteristics in the tuberling generation, especially if high specific gravity is a characteristic of the parents.

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